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PROCEEDINGS

OF THE

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Sixty-Eighth Session.

Monday, 3d *March* 1851.

Sir DAVID BREWSTER, K.H., Vice-President, in the Chair.

The following Communications were read:—

1. On Iron and its Alloys. Part I. By J. D. Morries Stirling, Esq.

2. On the Weight of Aqueous Vapour, condensed on a Cold Surface, under given conditions. By James Dalmahoy, Esq.

The paper was accompanied by two tables, containing the results of sixty-three experiments respecting the rate at which vapour condenses on a cold surface.

In planning the experiments, it was assumed that $C = m\,(f'' - f''')$, where C is the weight of moisture condensed on a surface of given area in a given time; f'' the tension of vapour at the dew-point; f''' the tension at the temperature of the condensing surface; m a co-efficient varying with the velocity of the current of air.

But, in the course of experiments, it was found that the co-efficient m was not constant, even when there was no sensible current; and that under this state of the air, it was necessary to change m into

M $(t - t''')$ in which M is constant, t the temperature of the air, and t''' the temperature of the condensing surface.

The principal object of the experiments was to determine mean values of the co-efficients m and M. The data and results necessary for this purpose were contained in the two tables before alluded to, and the following small table merely exhibits the mean values.

Mean Values.	Velocity of Current per 1″.	Number of Experiments.
M = 0·12	Insensible	15
m = 18·3	4·12 feet	11
m = 26·5	8·24	8
m = 39·7	14·8	8
m = 44·6	20·6	11

It is to be remarked, that the value of M, as given above, is only applicable when the air in contact with the cold surface is free to descend by its own weight, and that when, from any impediment to its escape, the air is not changed, there is scarcely any sensible condensation of vapour on the cold surface.

The paper concluded by examining, in connection with the preceding results, the theory proposed by Professor Phillips in explanation of the increment received by rain in the course of its descent to the earth. This theory, as is well known, ascribes the increment to to the continual condensation of vapour on the cold surfaces of the drops; and the author of this paper attempted to prove, that when the data assumed were the most favourable to the theory which the case admitted of, the observed increment of the rain was 635 times greater than would be accounted for by the rate of the experiments.

3. On the Poison of the Cobra da Capello. By Dr J. Rutherford Russell. Communicated by Dr Gregory.

The poison is of an amber colour, has a faint animal odour and an acrid taste. When treated with alcohol or ether it separates into two portions—the one soluble and the other insoluble. From some experiments Dr Russell made he concluded that both were poisonous, but is inclined to believe the soluble to be the more poisonous of the two.

He gave a detailed account of a series of experiments made upon some rabbits and a dog. The effect of the insertion of a small portion of the poison into a wound in a rabbit was in almost every case to produce death, generally preceded by stupor and sometimes by convulsions. The lungs were found gorged with blood in several

of the cases, and in some there was evidence of a severe inflammation of the pluræ having taken place. The poison took from an hour and a half to twenty-four hours to produce its fatal effect.

It produced little effect upon the dog, probably from the quantity being small.

The following Gentlemen were duly elected Ordinary Fellows:—

JOHN STEWART, Esq., of Nateby Hall, Lancashire.
Dr JOHN KINNIS, Deputy-Inspector of Hospitals.

The following Donations to the Library were announced:—

Medico-Chirurgical Transactions. Published by the Royal Medica and Chirurgical Society of London. General Index. Vols. I.–XXXIII. 8vo.—*From the Society.*

The Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. New Series. No. 32. 8vo. —*From the Society.*

Monday, 17*th March* 1851.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. On a New Source of Capric Acid, with Remarks on some of its Salts. By Mr T. H. Rowney. Communicated by Dr Anderson.

The author commences his paper by mentioning the different sources from which capric acid has been obtained, and then proceeds to point out a new source for obtaining it, namely, the grain oil from the Scotch distilleries.

The grain oil, he states, consists of water, alcohol, amylic alcohol, and an oily residue, having a much higher boiling point than amylic alcohol. It is this oily residue that contains the capric acid. He obtained it by boiling the only residue with caustic potassa, which renders it soluble in water, and by adding HO, SO, or HCl to the alkaline solution, the capric acid is separated. He then proceeds to detail the method he followed for obtaining it pure, and its most characteristic properties, viz.,—it is solid at the ordinary temperature, and fuses at 81° F.,—it is insoluble in cold water, and slightly soluble in hot water,—very soluble in cold alcohol and ether,—and

when a large quantity of cold water is added to the alcoholic solution, the capric acid separates in crystals. The numbers obtained by analysis shewed the formula to be $C_{20} H_{19} O_3 HO$.

The author then describes the salts of capric acid that he examined, —these were the silver, baryta, magnesia, lime, copper, and soda. He also obtained capric ether and capramide. The capric ether is an oily liquid, lighter than water, its specific gravity being ·862, insoluble in cold water, but readily soluble in alcohol and ether. The capramide he obtained by acting on the ether with a strong solution of ammonia. It forms beautiful crystalline scales, insoluble in cold water, soluble in cold alcohol, and also in dilute spirit, when warmed. Its formula he found to be $C_{20} H_{21} O_2 N$.

2. On Iron and its Alloys. Part II. By J. D. Morries Stirling, Esq.

The following abstract contains a brief notice of this as well as of the former part of Mr Stirling's paper, read at last meeting:—

The author gave a short description of the various kinds of cast-iron, and a statement respecting their strengths, and of the uses to which they are more especially adapted, pointing out the discrepancies which exist between chemists as to the quantity of carbon contained in each sort. That the author's experience led him to believe that the quantities of carbon were different in the different Nos.—greater in No. 1, less in Nos. 2, 3, and 4. Slow cooling of large masses of iron renders them softer. In making the mixtures of wrought and cast iron, different proportions of wrought-iron are used; for soft iron containing much carbon (or No. 1), more malleable-iron, and for harder iron, less. Welsh, Scotch, Staffordshire iron differing much from each other—the Scotch being the softest, the Welsh the hardest. By the proper proportioning the addition of malleable-iron, the strength of cast-iron is nearly doubled, both transversely and tensilely. By melting this mixture of wrought and cast iron, and then puddling the mixture, a very superior kind of wrought-iron is obtained, and the process of refining is avoided. By the addition of *calamine* or zinc to common iron, without the admixture of wrought-iron, a very superior malleable-iron is produced, equal in appearance, when twice rolled, to iron that has been thrice

rolled, and very much stronger, or as 28 to 24½. The increased strength in the mixture of wrought and cast iron, called toughened cast-iron, renders it peculiarly adapted for wheels, pinions, &c., and for girders, columns, and other architectural uses. Several government works so constructed—the Chelsea, the Windsor, and the Yarmouth Bridges—also, at various iron-works, all rolls, pinions, and cog-wheels are made of it. The wrought-iron made either from the toughened cast, or by the admixture of calamine, is particularly useful for tension rods, chain-cables, &c. The addition of antimony and some other metals to wrought-iron in the puddling furnace gives a hard and crystalline iron, nearly allied to steel in some of its properties, and is adapted, from its hardness and crystalline character, to form the upper part of railway rails and the outer surface of wheels. When thus united to the iron containing zinc, the best sort of rail results, combining strength, stiffness, and hardness with anti-laminating properties, and being also cheaper than any other kind of hardened rail or *tire*. Compounds of copper, iron, and zinc are found to be much closer in texture, and stronger than similar compounds of copper and zinc (the proportion of iron not usually exceeding 1½ per cent.), and can be advantageously used as substitutes for gun-metal, under all circumstances, for great guns, screws, propellers, mill brasses, and railway bearings; small additions of tin and other metals alter the character of these compounds, and render them extremely manageable as regards hardness and stiffness. The advantages which these compounds possess over gun-metal are cheapness and increased strength, being about one-fourth cheaper, and one-half stronger, and wearing much longer under friction. On many railways, the alloys of zinc, iron, copper, tin, &c., have superseded gun-metal for carriage bearings. An alloy equal in tone to bell-metal, cheaper, and at the same time stronger, is made from the alloy of copper, zinc, and iron, a certain proportion of tin being added. The addition of iron seems, under most, if not all circumstances, to alter the texture of metallic alloys, rendering it closer, and the alloys, therefore, more susceptible of a high polish, and less liable to corrosion. Other alloys of iron were exhibited, some shewing the extreme closeness of texture, others possessing very great hardness, and suitable for tools, cutting instruments, &c., others possessing a high degree of sonorousness. A bell was exhibited, of fine tone; its advantages being cheapness (less than half

the price of common bell-metal) and superiority of tone. Other alloys of iron, copper, zinc, manganese, and nickel were exhibited, some bearing a near resemblance to gold, others to silver; the latter being now most extensively made in Birmingham, and gradually superseding German silver, or at least being largely used instead of that alloy, which it surpasses in lustre, closeness of texture, and freedom from tarnish. A malleable bell was also shown, the tone of which was equal, if not superior, to that of a common bell of same size: a specimen of this sort of metal was shown crushed almost flat. The author recommended its use for ship and lighthouse bells, &c.

3. On the Dynamical Theory of Heat, with Numerical Results deduced from Mr Joule's Equivalent of a Thermal Unit, and M. Regnault's Observations on Steam. By William Thomson, M.A., Fellow of St Peter's College, Cambridge, and Professor of Natural Philosophy in the University of Glasgow.

Sir Humphrey Davy, by his experiment of melting two pieces of ice by rubbing them together, established the following proposition:—

"The phenomena of repulsion are not dependent on a peculiar elastic fluid for their existence, or caloric does not exist;" and he concludes that heat consists of a motion excited among the particles of bodies. "To distinguish this motion from others, and to signify the cause of our sensation of heat," and of the expansion or expansive pressure produced in matter by heat "the name *repulsive motion* has been adopted."*

The Dynamical Theory of Heat, thus established by Sir Humphrey Davy, is extended to radiant heat by the discovery of phenomena, especially those of the polarization of radiant heat, which render it excessively probable that heat propagated through vacant space, or through diathermane substances, consists of waves of transverse vibrations in an all-pervading medium.

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* From Davy's first work, entitled "An Essay on Heat, Light, and the Combinations of Light," published in 1799 in "Contributions to Physical and Medical Knowledge, principally from the West of England; collected by Thomas Beddoes, M.D.," and republished in Dr Davy's edition of his brother's collected works, vol. ii. London, 1836.

The recent discoveries* of the generation of heat through the friction of fluids in motion, and by the magneto-electric excitation of galvanic currents would, either of them, be sufficient to demonstrate the immateriality of heat, and would so afford, if required, a perfect confirmation of Sir Humphrey Davy's views.

Although Sir Humphrey Davy had established beyond all doubt the fact that heat may be created by mechanical work, the converse proposition, that heat is lost when mechanical work is produced from thermal agency, appears to have been first enunciated by Mayer in 1841. In 1842 the same proposition was enunciated by Joule, and a number of most admirable experiments illustrating the mutual convertibility of heat and mechanical effect, and the constancy of thermal effects through the most varied means, from given causes, are described in his paper on Magneto-electricity, and adduced in it from his former experimental researches by which the laws of the evolution of heat by the galvanic battery had been established. The same paper contains the first investigation on true principles that has ever been made of the numerical relations which connect heat and mechanical effect; and numerical determinations of "the mechanical equivalent of a thermal unit" are given as the results of two classes of experiments, in each of which mechanical work is spent, and no other final effect than the creation of heat is produced, in one class by means of magneto-electric currents, and in the other, by means of the friction of fluids in motion.

In subsequent experimental researches he has made more accurate determinations, and, from his last set of experiments on the friction of fluids, he concludes "that the quantity of heat capable of raising the temperature of a pound of water (weighed *in vacuo* and taken at between 55° and 60°) by 1° Fahr., requires for its evolution the expenditure of a mechanical force represented by the fall of 772 lb. through the space of one foot."

* In May 1842, Mayer announced, in the Annalen of Wöhler and Liebig, that he had raised the temperature of water from 12° to 13° cent., by agitating it. In 1843, Joule announced in the Philosophical Magazine that "heat is evolved by the passage of water through narrow tubes;" and in the month of August of that year (1843), he announced to the British Association that heat is generated when work is spent in turning a magneto-electric machine, or an electro-magnetic engine. (See his paper "on the Calorific Effects of Magneto-Electricity and on the Mechanical Value of Heat." Phil. Mag. vol. xxiii. 1843.)

The object of the present paper is threefold—

(1.) To show what modifications of the conclusions arrived at by Carnot, and by others who have followed his peculiar mode of reasoning regarding the motive power of heat, must be made when the hypothesis of the Dynamical Theory, contrary as it is to Carnot's fundamental hypothesis, is adopted.

(2.) To point out the significance in the Dynamical Theory, of the numerical results deduced from Regnault's observations on steam, and communicated about two years ago to the Society with an Account of Carnot's Theory, by the author of the present paper; and to show that, by taking these numbers (subject to correction when accurate experimental data regarding the density of saturated steam shall have been afforded), in connection with Joule's mechanical equivalent of a thermal unit, a complete theory of the motive power of heat, within the temperature limits of the experimental data, is obtained.

(3.) To point out some remarkable relations connecting the physical properties of all substances, established by reasoning analogous to that of Carnot, but founded on the contrary principle of the Dynamical Theory.

In the first part of the paper Mr Joule's principle regarding the mechanical equivalent of heat is shown to be in reality as certainly true as Carnot's would be if the hypothesis that heat is matter were not false; and it is therefore adopted by the author, not as Carnot's principle was adopted by him temporarily "as the most probable basis for an investigation of the motive power of heat" without a belief in its rigorous exactness; but, with implicit confidence, as a true law of nature.

The following axiom is also adopted:—

It is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects.

From Joule's principle, and from this axiom, the two following propositions, which constitute the foundation of the theory, are deduced.

Prop. I.—When equal quantities of mechanical effect are produced by any means whatever from purely thermal sources, or lost in purely thermal effects, equal quantities of heat are put out of existence, or are generated.

Prop. II.—If an engine be such that when it is worked backwards the physical and mechanical agencies in every part of its

motions are all reversed, it produces as much mechanical effect as can be produced by any thermo-dynamic engine with the same temperatures of source and refrigerator, from a given quantity of heat.

The second of these propositions was first enunciated by Carnot, and demonstrated by him on the assumption of his principle of the permanence of heat. It was first enunciated and demonstrated, without making that assumption, upon the true principles of the dynamical theory, by Clausius, in the second part of his paper* (published in May 1850), who founds it on an axiom substantially equivalent to that quoted above. The author of the present paper gives the demonstration, which is closely analogous to Carnot's original demonstration, and the axiom on which it is founded, just as they occurred to him at a time when he was only acquainted with the first part (published in April 1850) of Clausius' paper, and was not aware that the proposition had been either enunciated or demonstrated except by Carnot.

From the establishment of the second proposition, on the principles of the dynamical theory, and an axiom that cannot probably be denied, it is shown that all the conclusions obtained by Carnot and others who have followed him and adopted his principles, which depend merely on the fundamental equation expressing "Carnot's function," in terms of certain physical properties of any substance whatever, require no modification.

But the Theory of the motive power of heat through finite ranges of temperature requires most important alterations which form the subject of the second part of the present paper. The following expressions are given for the amount of work (W) derivable from a unit of heat introduced into an engine at the temperature S, if the coldest part of the engine is at the temperature T; in terms of the portion (1 – R) of the unit of heat which is converted into work, and for the remainder, (R,) which is emitted as waste into the refrigerator.

$$W = J\,(1 - R);$$

$$R = \epsilon^{-\frac{1}{J}\int_T^S \mu\, dt};$$

where J denotes the "mechanical equivalent" of a unit of heat determined by Joule.

* Poggendorff's Annalen, 1850.

Tables of the values of these quantities, for different ranges, obtained by using the values of μ shown in Table I. of the author's Account of Carnot's Theory, are given. An application to the case of the Fowey-Consols engine which, according to the data quoted in the Appendix to that paper, appears to have worked at 76 per cent. of the true duty for its range of temperature (which was assumed to be from 30° to 140° cent.), instead of only 67 per cent. of the duty according to Carnot's Theory; and to have emitted into the condenser only 82 per cent. of the heat taken in at the boiler, the remaining 18 per cent. having been converted into mechanical effect.

It is shown that the advantage originally pointed out by Carnot may be still anticipated from the use of air instead of steam, as the effective range of temperature of the air-engine can be made much greater than is practicable in the case of the steam-engine. As an example of the economy attainable by using a large range, it is shown that, with a range of from 0° to 600° cent., about three-fourths of the full equivalent is attainable by a perfect engine, while with the range from 30° to 140°, which is about the greatest that is practicable with steam-engines, even a perfect engine could not obtain more than 27, or about one-fourth of the full equivalent of the heat used.

The third part of the paper contains investigations of some formulæ with reference to the specific heats of substances of any kind, derived from the equations which express the two fundamental propositions. It contains also an application of these equations to the case of a medium consisting of two parts, of the same substance, at the same temperature, in different states. The results are applicable both to the effects of pressure on the melting points of solids, and to the conditions of saturated vapours. One of the conclusions pointed out is, the very remarkable property of saturated steam, that its "specific heat is negative," which was discovered independently by Rankine and Clausius.

The following Donations to the Library were announced:—

Philosophical Transactions of the Royal Society of London, for the year 1850. Part 2, 4to.—*From the Society.*

Observations on Days of unusual Magnetic Disturbance, made at the British Colonial Magnetic Observatories, under the depart-

ments of the Ordnance and Admiralty. Vol. I., Part 2. (1842–4), 4to.—*From the British Government.*

Annales des Mines. Tom. II. (1847); Tom. IV., Liv. 1, 5, 6, (1833); Table des Matières des 1re et 2e Séries, 1816–30; Tom. XIV., Liv. 6 (1848); Tom. XIX., Liv. 1, 2, 3, (1841); Tom. XX., Liv. 4, 5, 6 (1841); 8vo.—*From the Ecole des Mines.*

Journal of the Statistical Society of London. Vol. XIV., Part 1, 8vo.—*From the Society.*

The Geological Observer. By Sir Henry T. de la Bèche. 8vo. —*From the Author.*

Journal of the Asiatic Society of Bengal. No. 214. 8vo.—*From the Society.*

Monday, 7th April 1851.

SIR DAVID BREWSTER, K. H., Vice-President, in the Chair.

The following Communications were read :—

1. On the Geology of the Eildon Hills. By Professor J. D. Forbes.

The author first refers to a paper by Mr Milne, in the 15th Volume of the Edinburgh Transactions, on the Geology of Roxburghshire, in which the general features of this district are accurately described. The present paper contains a notice of some minuter particulars regarding the formation of the Eildon group and their boundaries obtained by detailed personal examination in 1849.

The remarkable general parallelism of the strata of greywacké which forms the basis of the geology of the neighbourhood, is first particularly insisted upon. The intrusive rocks, chiefly felspathic, which abound near Melrose, have but little, if at all, disturbed the general strike and inclination of the greywacké rocks, the former being in a direction nearly east and west, and the latter nearly vertical. The triple Eildon Hill is composed principally of brownish red felspar porphyry, sometimes resembling clink-stone, at other times containing quartz; the south-western hill shews vertical columns of the same substance. The author was able to trace the strata of greywacké to a great height on the north-western face of the two

principal Eildons; to a level in fact within two or three hundred feet of the *col* or neck which unites them; but the principal feature which he insists upon is, that the highest summit of the group appears to be composed of a mass of greywacké rock, caught up in the midst of the surrounding trap, and so metamorphosed by it as to be with difficulty recognisable; but the author considers that he has obtained a suite of specimens which leave no doubt as to the fact of the gradation.

The other important trap-rock is the trap-tufa of Melrose, of which the nature and extent were carefully examined, although the latter is still subject to doubt. The formation appears to commence close to the railway station at Melrose, and to extend in a westerly direction towards Cauldshiels Loch, its breadth being in the Rhymer's Glen still considerable, but no section which shews it could be obtained farther west. To the south of the trap-tufa behind Melrose, there occurs a remarkable patch of red sandstone, horizontally deposited, and evidently identical with that of Dryburgh, where trap-tufa also occurs. There can be little doubt but that the tufa is posterior in date to this sandstone, whilst the Eildon porphyry is older.

A collection of specimens, illustrating the paper, is deposited in the Museum of the Royal Society.

2. On certain Salts of Comenic Acid. By Mr Henry How. Communicated by Dr Anderson.

The author commenced his paper with a few observations on the comparative progress of the different departments of organic chemistry, and remarked that the subject of the polybasic acids is not so completely studied as could be wished, and that he had chosen his subject for investigation in the hope of adding some information on that point.

After giving a short history of comenic acid, he pointed out a new method for the purification of the crude acid, which consisted in the use of ammonia as a solvent, in place of potass. In this way he got a salt readily deprived of colour, and whose impure mother liquors were of use in subsequent experiments.

He then proceeded to detail the salts he had examined. The bicomenate of ammonia, just mentioned, was a salt, crystallizing in beautiful brilliant colourless prisms, whose formula is

$$NH_4\,O, HO, C_{12}\,H_2\,O_8 + 2\,HO.$$

They lose their water of crystallization at 212°.

The corresponding salts of potass and soda crystallize in prismatic groups; they are anhydrous, and their respective formulæ are

$$KO, HO, C_{12} H_2 O_8,$$
$$NaO, HO C_{12} H_2 O_8.$$

He proved the non-existence of neutral alkaline salt,—but shewed that both neutral and acid salts are formed with all the alkaline earths.

The acid lime-salt crystallizes from boiling water in transparent rhombs, whose composition is expressed by the formula

$$CaO, HO, C_{12} H_2 O_8 + 7 \text{ aq.}$$

The 7 aq. are expelled at 250° Fahr.; the neutral salt of lime is insoluble in water, and its constitution is

$$2 CaO, C_{12} H_2 O_8, 2 HO + 5 \text{ aq., or}$$
$$2 CaO, C_{12} H_2 O_8, 2 HO + 11 \text{ aq.,}$$

according as the fluids from which it is deposited are more or less dilute; the aq. is driven off at 250° Fahr.

The bicomenate of baryta crystallizes from hot water in transparent rhombs; their composition is

$$2 (BaO, HO, C_{12} H_2 O_8) + 13 \text{ aq.}$$

The 13 aq. are lost at 212° Fahr.; the neutral barytic salt is insoluble in water, and has the formula

$$2 BaO, C_{12} H_2 O_8 + 2 HO + 8 \text{ aq.}$$

The 8 aq. are expelled at 250° Fahr.

The bicomenate of magnesia crystallizes from water in crystals very like ferrocyanide of potassium; their composition is

$$MgO, HO, C_{12} H_2 O_8, 2 HO + 6 \text{ aq.}$$

The 6 aq. being driven off at 240° Fahr., the neutral magnesia salt is insoluble in water, and has the constitution

$$2 MgO, C_{12} H_2 O_8, 3 HO + 8 \text{ aq.}$$

The 8 aq. are lost at 212° Fahr.

After making a few remarks on some other salts, the author pro-

ceeded to discuss the products of decomposition of comenic acid. He first shewed that it readily undergoes oxidation by nitric acid, and by solution of persulphate of iron, with the production of carbonic and oxalic acids in both cases, and elimination of hydrocyanic acid in the former.

No change is produced by the action of sulphurous acid, or of sulphuretted hydrogen.

When chlorine acts upon comenic acid or solution of bicomenate of ammonia, a new acid is produced, crystallizing in fine brilliant square prismatic needles: analysis shewed the composition to be

$$2\ HO, C_{12} \left\{ \begin{matrix} H \\ Cl \end{matrix} \right\} O_8 + 3\ HO.$$

The three atoms of water are expelled at 212°; in the formula of the anhydrous acid, we have that of comenic acid, in which an equivalent of hydrogen is replaced by chlorine.

This is a strong and bibasic acid, forming two series of salts: the author, after detailing the properties and products of decomposition of the acid itself, describes the appearance of some of these salts, and gives the analysis of those of silver, whose composition he shews to be

For the acid, $AgO\ HO,\ C_{12} \left\{ \begin{matrix} H \\ Cl \end{matrix} \right\} O_8$ and

For the neutral, $2\ AgO,\ C_{12} \left\{ \begin{matrix} H \\ Cl \end{matrix} \right\} O_8$.

The action of bromine is precisely similar, and furnishes an acid of the same character, appearance, and properties: its formula is

$$2\ HO, C_{12} \left\{ \begin{matrix} H \\ Br \end{matrix} \right\} O_8 + 3\ HO.$$

It loses its water of crystallization at 212°.

Some account is given of the salts of bromocomenic acid; and the author then goes on to examine the action of hydrochloric acid gas upon absolute alcohol holding comenic acid in suspension. He details the process by which he obtains a substance which is evidently comenovinic acid, analogous to tartrovinic, sulphovinic acid, and such bodies. It has the composition

$$HO,\ C_4\ H_5\ O,\ C_{12}\ H_2\ O_8.$$

It has an acid reaction, coagulates white of egg, &c., fuses and sub-

limes unaltered; but, though stable *per se*, is readily decomposed in presence of fixed bases: for this reason only the ammonia salt could be obtained, and that in a peculiar way; sufficient evidence was given, however, of its being a true salt of the constitution

$$NH_4\,O,\ C_4\,H_5O,\ C_{12}\,H_2\,O_8.$$

The author then gives a description of a curious change which ensues when an alkaline ammoniacal solution of comenic acid is boiled, and which results in the production of comenamic acid, which he shews to be constituted like osamic acid, it being an acid amide. It is derived from the bicomenate of ammonia by the elimination of two atoms of water; consequently, its formula, as proved by analysis, is

$$HO,\ C_{12}\,H_4\,NO_7.$$

It crystallizes with four equivalents of water in beautiful micaceous scales: its most distinctive property is the magnificent purple colour it forms with persalts of iron.

It forms crystallizable salts with a certain proportion of potass, soda, or ammonia, which have an acid reaction.

The formula of the ammonia salt is

$$NH_4\,O,\ C_{12}\,H_4\,NO_7.$$

The corresponding salt of silver is transparent and jelly-like; that of baryta crystallizes readily; its composition appears to be

$$BaO,\ C_{12}\,H_4\,NO_7 + 2\,HO.$$

A solution of the ammonia salt made alkaline gives with nitrate of silver a yellow precipitate, which speedily becomes black,—and with chlorine of barium, an insoluble white precipitate, which may be considered as having the composition expressed in the formula

$$BaO,\ C_{12}\,H_4\,NO_7 + BaO\,HO.$$

The author concludes, by saying he believes he has observed in the behaviour of comenamic acid, under certain circumstances, phenomena which will repay further investigation.

3. On the Crystallization of Bicarbonate of Ammonia in Spherical Masses. By Dr G. Wilson.

The author exhibited these spherical concretions, which had formed

in a subliming chamber, where carbonate of ammonia from gas liquor was condensed; apparently in consequence of a local whirl affecting the condensing particles. They were formed of acicular crystals, confusedly grouped, without a trace of radiation or of any regular arrangement.

4. On the Compressibility of Water. By W. J. Macquorn Rankine, Esq., C.E.

The results of the experiments of M. Grassi on the above subject (Comptes Rendus XIX.) follow sensibly this law.

The compressibility of water is inversely proportional to the density, multiplied by the temperature as measured from the absolute zero of a perfect-gas thermometer, viz. :—a point 274°·6 below the ordinary zero of the centigrade scale, and 462°·28 below that of Fahrenheit's scale.

Hence the compressibility of water follows sensibly the same law with that of a gas.

Let $\mathfrak{d}$ be the compressibility of water per atmosphere; D its density, the maximum density being unity; τ the absolute temperature, then

$$\mathfrak{d} = \frac{1}{K \tau D}$$

where

K = 72 atmospheres per centigrade degree, or
40 atmospheres per degree of Fahrenheit.

D may be computed by the author's formula for the expansion of liquids.—(*Edinburgh New Philosophical Journal, October* 1849.)

Dr Gregory read a letter from his Grace the Duke of Argyll, describing the locality of a white muddy deposit sent with the letter, and exhibited in a dry state to the Society. The deposit occurs in what appears to be an old channel between Loch Baa, at the foot of Ben More in Mull, and the sea, passing through a dead flat. The lake discharges itself now by another channel. Dr Gregory found the deposit to be silicious, with a trace of organic matter, and to consist entirely of the silicious cuirasses of infusoria, like the bergmehl of Sweden. Navicula viridis, and some bacillaria had been observed in it by Dr Gregory, and Dr Douglas Maclagan, who undertook a microscopical examination, found, besides Navicula viridis,

several species of Eunotia, and the beautiful rings of Gallionella varians. The deposit occurs in the old channel to a very considerable depth, a long stick having failed to reach the bottom of the white mud.

The following Gentleman was duly elected an Ordinary Fellow :—

Elmslie William Dallas, Esq.

The following Donations to the Library were announced :—

Primo Decennio di Osservazioni Meteorologiche fatto nella Specula di Bologna, ridotte esposte ed applicate da Alessandro Palagi, M.D. 4to.—*From the Author.*

Neue Denkschriften der Allgemeine Schweizerischen Gesellschaft für die gesammten Naturwissenschaften. Bd. 11. 4to.

Mittheilungen der Naturforschenden Gesellschaft in Bern. Nos. 144–192. 8vo.—*From the Society.*

Verhandlungen der Schweizerischen Naturforschenden Gesellschaft bei ihrer 35 Versammlung in Aarau. 1850–1. 8vo.

Verhandlungen der Schweizerischen Naturforschenden Gesellschaft bei ihrer 34 Versammlung in Frauenfeld. 1849. 8vo.—*From the Society.*

Naturwissenschaftliche Abhandlungen gesammelt und durch subscription herausgegeben von W. Haidinger. Bde. 2 and 3. 4to.

Berichte über die Mittheilungen von Freunden der Wissenschaften in Wien. herausg. von W. Haidinger. Bde. 3, 4, 5, 6. 8vo.—*From the Editor.*

Contribution to the Vital Statistics of Scotland. By James Stark, M.D. 8vo.—*From the Author.*

Journal of the Asiatic Society of Bengal. Nos. 215 and 216. 8vo. —*From the Society.*

Mémoires de l'Institut de France. Académie des Sciences. Tom. 20, 21, 22. 4to.

Mémoires présentés par divers Savants à l'Académie des Sciences de l'Institut National de France. Tom. 11, 12. 4to.—*From the Academy.*

Collection of Specimens illustrating the Geology of the Eildon Hills. —*By Professor Forbes.*

Monday, 21*st April* 1851.

DR CHRISTISON, Vice-President, in the Chair.

The following Communications were read :—

1. On the Economy of Single-acting Expansive Steam Engines, and Expansive Machines generally; being Supplements to a Paper on the Mechanical Action of Heat. By W. J. M. Rankine, Esq., C.E.

The author, in the first place, states the equations, which, when used in conjunction with the Tables in the Appendix to the original paper referred to, serve to compute the action of Cornish pumping engines. They are similar in form to those of M. de Pambour, but differ in the expressions for the pressure and volume of steam, and for its expansive action, which the author in the original paper deduced from theory.

Let A denote the area of the piston.

l, the length of the stroke.

n, the number of double strokes in unity of time.

c, the fraction of the whole bulk of steam above the piston at the end of a down stroke, which is employed in filling the valve-boxes and the clearance of the cylinder.

l', the length of stroke performed, when the steam is cut off.

s, the ratio of expansion of the steam, so that

$$\frac{1}{s}=(1-c)\frac{l'}{l}+c\,;\ \frac{l'}{l}=\frac{\frac{1}{s}-c}{1-c}.$$

Let W be the weight of steam expended in unity of time.

P_1, the pressure at which it enters the cylinder.

V_1, the corresponding volume of unity of weight of steam, which may be found by means of Table I., already referred to.

F, the resistance per unit of area of piston not depending on the useful load.

R, the resistance per unit of area of piston arising from the useful load.

Z, the ratio of the total action of the steam at the expansion s, to its action at full pressure; which may be found from Table II.

E, the useful effect in unity of time.

The moment of closing the equilibrium-valve is supposed to be so adjusted, whether by trial or by calculation, as to prevent any sensible loss of power from clearance and steam passages. Let l'' be the portion of up-stroke, remaining to be performed at the proper moment for closing this valve, then

$$\frac{l''}{l} = \frac{c\,(s-1)}{1-c}$$

This adjustment being made, the two following are the fundamental equations of motion of the engine :—

$$E = R\,A\,l\,n = W\,V_1\,(P_1\,Z - F) = \text{useful effect in unity of time.}$$

$$W = \frac{A\,l\,n}{V_1\,s} = \text{steam expended in unity of time.}$$

The following are deduced from them. Ratio of mean load to maximum pressure :—

$$\frac{R+F}{P_1} = \frac{Z}{s}\,;$$

Duty of unity of weight of steam—

$$\frac{E}{W} = V_1\,(P_1\,Z - F)\,;$$

Weight of steam expended per stroke—

$$\frac{W}{n} = \frac{A\,l}{V_1\,s}\,.$$

The results of the last two formulæ are compared with the experiments made by Mr Wicksteed on a large Cornish pumping-engine at Old Ford at five different ratios of expansion; and the agreement is found to be so close as to prove that the results of the theory are practically correct.

The results of experiment generally shew a somewhat less expenditure of steam for a given duty than theory indicates. This is conceived to arise from the cylinder being heated by a jacket communicating with the boiler, in which the temperature is much higher than the highest temperature in the cylinder.

The theory is next applied to the solution of the problem of the economy of Cornish engines. The merit of first proposing this problem is believed to belong to the Artizan Club, who have offered premiums for its solution, "with a view," as they state, "to enable

" those who, from their position, cannot take part in the discus-
" sions of the various scientific societies to give the profession the
" benefit of their studies and experience." As the author's paper will not be published until some time after the date fixed by the Artizan Club for receiving Essays, he expresses a confident belief that it will not be considered as interfering with their design.

The problem in question is this; given the following—

P_1, the initial pressure in the cylinder.

F, the resistance independent of the useful load.

$l\,n$, the amount of the length of the effective strokes in unity of time.

h, the annual cost of producing unity of weight of steam per unit of time, which consists of two parts, cost of fuel and interest of cost of boilers.

k, the annual interest of the cost of the engine, per unit of area of piston.

It is required to determine the ratio of expansion s (and thence the dimensions of the engine), such that the annual expense due to interest and fuel

$$h\,W + k\,A$$

shall be a minimum as compared with the useful effect E.

This condition is fulfilled by making the ratio

$$\frac{Z - \frac{F}{P_1} S}{\frac{h\,l\,n + S}{k\,V_1}}$$

a maximum.

This problem is solved graphically, by drawing two straight lines on a diagram, a copy of which is annexed to the paper on a scale large enough for practical purposes.

The following formulæ serve to compute the dimensions of the engine.

Mean resistance of the useful load per square foot of piston :—

$$R = \frac{Z}{s} P_1 - F$$

$$\text{Area of piston} = A = \frac{E}{R\,l\,n}$$

Expenditure of steam per unit of time,—

$$W=\frac{E}{R V_1 s}.$$

A numerical example is added of the solution of this problem of economy.

The next portion of this paper relates to the proportion of heat converted into expansive power by machines.

A machine working by expansive power consists essentially of a portion of some substance which alternately expands and contracts under the influence of heat; receiving heat and expanding at a higher temperature; emitting heat and contracting at a lower.

The quantity of heat emitted is less than the quantity received, the difference being transformed into expansive power. To make the proportion of heat thus transformed a maximum, the temperatures of reception and emission should each be a constant quantity, so that none of the heat received or emitted may be employed in producing changes of temperature. The temperature must be raised and lowered by compression and expansion only.

Carnot was the first to assert the law, that when a machine works under these conditions, the ratio of the power evolved to the heat originally received, is a function of the temperatures of reception and emission only, and independent of the nature of the working substance. But his investigation not being founded on the principle of the mutual conversion of heat and power, involves the fallacy that power can be produced out of nothing.

The merit of combining Carnot's law with that of the convertibility of heat and power, belongs to M. Clausius and Professor William Thomson.

The author, having applied to this question the principles laid down in the introduction and first section of his paper on the Mechanical Action of Heat, has arrived at the following conclusions:—

First.—Carnot's law is not an independent principle in the theory of heat, but is deducible as a consequence from the equations of the mutual conversion of heat and expansive power given in the first section.

Secondly.—The maximum value of the ratio of the quantity of

heat converted into expansive power to the total quantity received by the body, is equal to that of the difference between the temperatures of reception and emission, to the absolute temperature of reception diminished by a certain constant denoted by $\varkappa = C\, n\, \mu\, b$ in the paper; which constant must be the same for all substances in nature, in order that molecular equilibrium may be possible. That is to say, let τ_1 be the absolute temperature at which heat is received, and τ that at which it is emitted; then

$$\frac{\text{maximum of heat transformed into power}}{\text{total heat received}} = \frac{\tau_1 - \tau_0}{\tau_1 - \varkappa}$$

The value of $\varkappa$ is as yet unknown, but as an approximation it may be treated as small enough to be neglected in comparison with τ_1.

Although this formula is very different from Professor Thomson's in appearance, the numerical results are nearly the same.

The conditions of working to which Carnot's law is strictly applicable are not attainable in the steam-engine, and are different from those on which the author's formulæ and tables in the fourth section are based. The proportion of heat converted into power in the steam-engine is therefore found, both by experiment and by calculation, to be less than that indicated by Carnot's law. The author illustrates this fact by examples, theoretical and experimental.

2. On the Products of the Destructive Distillation of Animal Substances. Part II. By Dr Anderson.

The author commenced by referring to the first part of his paper, in which he had determined the existence, among the products of destructive distillation of animal substances, of picoline, which he had before obtained from coal-tar, and of a new base to which he had given the name of Petinine; and had also indicated the existence of certain other bases. On proceeding to the further investigation of these substances, he had been much impeded by deficiency in materials, and had, at length, been compelled to operate on no less than 250 gallons, or about a ton of bone oil.

By separating the bases in a manner similar to that employed in his first experiments, but with some modifications detailed in the

paper, the author had succeeded in obtaining a great variety of products which had escaped his notice when operating on a smaller scale. Among the most volatile products, and accompanying ammonia, he had detected the presence of a base of the formula $C_2 H_5 N$, and which had all the properties of methylamine. He had also determined the presence of propylamine $C_6 H_9 N$, and rendered probable the existence of ethylamine $C_4 H_7 N$.

In the examination of the bases boiling at higher points great difficulties had been experienced, and even after many rectifications the indications of fixed boiling points were extremely indistinct, but, by the examination of the platinum salts, the author ascertained the existence of a base boiling at about 250°, having the formula $C_{10} H_5 N$, for which he proposed the name of Pyridine, and of another boiling about 310°, which has the formula $C_{14} H_9 N$, and has the constitution of toluidine, but differs entirely from it in properties. To this base the author gives the name of Lutidine.

At the close of the paper the author also refers shortly to the existence of an entirely different series of bases, to which he gives the provisional name of *Pyrrol Bases*, which are distinguished by the property of splitting up, under the action of strong acids, into a red resinous matter, and one or other of the bases of the picoline series.

3. On Carmufellic Acid. By Dr Sheridan Muspratt and Mr Danson.

In this paper the authors, after mentioning the various researches hitherto made on cloves and the substances therein discovered, describe the preparation of the new acid.

20 lb. of cloves are extracted by boiling water, and the decoctions, after being concentrated to six gallons, were acted on by nitric acid, first in the cold, afterwards with the aid of heat. The action is brisk, and irritating vapours are given off, which affect the eyes strongly. Oxalic and carbonic acids are also formed. A white deposit is separated by filtration, and the filtered liquid, on evaporation, yields yellow micaceous scales of the acid, which are obtained colourless by combining it with lead and separating it by sulphuretted hydrogen.

The acid is insoluble in alcohol, ether, and cold water, but soluble

in hot ammonia, potash, and large quantities of boiling water. It forms gelatinous salts with the solutions of salts of baryta, strontia, or lime, and also with those of lead; green flakes with salts of copper; yellow flakes with sesquisalts of iron; white flakes with salts of protoxide of iron and silver. These precipitates shrink much in drying, feel like mica, and dissolve in nitric and hydrochloric acids.

The analyses of the acid yielded results indicating the formula $C_{24} H_{20} O_{32}$. The baryta and lead salts appear to contain the acid entire, which is unusual, their formula being $MO, C_{24} H_{20} O_{32}$, instead of the base replacing an equivalent of water.

The authors are occupied with eugenic acid and the neutral oil of cloves.

4. Farther Remarks on the Intermitting Brine Springs of Kissingen. By Professor Forbes.

On the 7th of January 1839, I communicated to the Royal Society of Edinburgh a pretty detailed account of the singular mineral and gas springs of Kissingen, in Bavaria, then much less known than at present to English travellers. I refer to this paper, printed in the Edinburgh New Philosophical Journal, April 1839, for the details of the most curious of these, a saline spring called Kunde-Brunnen, which was at that time regularly periodic; a copious and turbulent discharge of brine, mixed with torrents of carbonic acid gas, recurring six or eight times in the twenty-four hours. This phenomenon, exactly as described in my paper, appears to have continued with slight variation ever since, that is, for a period of twelve years, subject, however, to the variation formerly mentioned, that when the brine is actively withdrawn by pumps, for the manufacture of salt, the periods lengthen. I have no additional observations of importance to offer on this spring, beyond the remarkable fact of the continuity of these variations, surely the more remarkable when we recollect that the spring is entirely artificial, rising through an Artesian bore 312 Bavarian feet deep.

Much greater changes have taken place in the Schönborn Quelle, briefly referred to in my former paper as having a depth of 550 Bavarian feet, as overflowing once in seven or eight minutes, and yielding a feeble supply of weak brine, containing only one and a

half per cent. of salt. The boring process has been carried on, though slowly, nearly ever since, and it is at present one of the deepest Artesian bores ever made, being, at the time of my visits, 1878 feet. The bore passes first through *Bunter Sandstein* (which forms the bed of the valley, the surrounding heights being capped by muschel kalk and keuper), to a depth of 1240 feet; the only spring met with in that space being the small salt spring which existed in 1838, which occurred at a depth of 222 feet, with a temperature of 8° Reaumur; it yielded only 6 cubic feet per minute, with $1\frac{1}{4}$ per cent. of salt. On piercing the sandstone from between it and the gres vosgien rose a powerful spring, containing $2\frac{1}{2}$ per cent. of salt, of a temperature of 15° Reaumur, or 66° Fahr., and yielding from 93 to 100 cubic feet of water per minute, and probably quite as much carbonic acid gas. These fluids were driven up the shaft with enormous force by subterranean pressure.

Not satisfied with this considerable success, the intelligent inspector, Mr Knorr, continued the laborious and expensive work of boring, in the confident hope of reaching, if not the bed of salt, at least the spring of stronger brine. At 1590 feet the upper limit of the zechstein or magnesian limestone was reached, and at 1680 feet a source of carbonic acid gas appeared, which increased the height to which the water could be driven up. At last, at 1740 feet, the limits of the rock salt formation was attained, the boring irons bringing up saliferous clay, mixed with gypsum and anhydrite, which continued down to the depth of 1878 feet, and which is capable of impregnating the salt water to saturation, coming up charged with between 27 and 28 per cent. of salt. It is to be observed, however, that it is only that portion of the spring rising at 1240 feet which can descend to the bottom and then rise up in this state of saturation. The greater part retains its old per-centage of $2\frac{1}{2}$. It is therefore of urgent consequence to continue the bore until a spring has been reached at a lower level than the salt, and of sufficient power to rise through it to the surface, and in that way alone can this mineral treasure be made available for use; and as the thickness of the rock salt formation is supposed to be 700 or 800 feet, it may be long yet before this object is obtained. At present, if I understand right, the spring is not, properly speaking, intermittent, but it may easily be rendered so by a singular artifice which I saw put in practice. When the workmen wish to stop the flow of water, in

order to proceed with the boring, they surround the rods with a plug of clay bandaged with cloth, so that by lowering it into the bore-hole, which contracts at a certain depth, they stop it as when one corks a phial. In an instant all is still, the turmoil of water foaming with gas is at an end; and this tranquillity lasts for many days, and when the spring again rises, it may be stopped out in a similar way. Inspector Knorr thinks that he has established a kind of law in these remissions to this effect, that the number of days which elapse before the spontaneous return of the spring is *thrice* the number during which it had before flowed. Thus, if the spring has been allowed to rise uninterruptedly for five days, and is then stopped, it will remain fifteen days out.

Under ordinary circumstances, the gas and water exhaust their projectile force in a cauldron or shaft of considerable depth and width, in which the Artesian bore terminates; but Mr Knorr gave us an opportunity of witnessing its ascensional power, by fitting a tube into the entrance of the bore, thus leading it up to the surface of the ground; it then spouted from that level to a height of at least 50 feet in the free air, having at its emission a diameter equal to that of a man's thigh. When we consider that it has first to rise 1240 feet through the earth, and that it is impelled by a mysterious and unseen, but apparently exhaustless, power beneath, and with this astonishing force, the phenomenon is certainly very surprising.

I shall only add the temperatures of some remarkable springs, taken in 1850 with great care, and which are the very same with those observed by me twelve years previous, the results of which may be found in my former paper.

Schönborn Quelle (Saline) 93 cubic feet per minute.

		Therm.		Corrected.
1850.	June 25, 5 P.M.	67°·2′	A 3.	
	„ 26, 4 P.M.	66·8	Troughton.	66·3

Ragozzi (Medicinal.)

June 26, noon	52·05	Troughton.	51·55
July 2, 5 P.M.	52·25	do.	51·75

Pandur (Medicinal.)

June 26, noon.	51·8	do.	51·3
July 2, 5 P.M.	52·0	do.	51·5

		Therm.	Corrected.
Max-Brunnen (Medicinal.)			
1850.	July 2, Noon.	49·4 Troughton.	48·9
Bocklet (Four miles from Kissingen, Chalybeate.)			
	July 1, 4 P.M.	50·7 Troughton.	50·2
Kapelle (Chapel at Kissingen, fine fresh-water spring in front of, accompanied by much gas.)			
	June 28, 6 P.M.	51·5 A 3.	

The above agree usually within a few tenths of a degree with the observations made fully a month later in 1838.

5. On a Method of Discovering Experimentally the Relation between the Mechanical Work spent and the Heat produced by the Compression of a Gaseous Fluid. By Professor William Thomson.

The important researches of Joule on the thermal circumstances connected with the expansion and compression of air, and the admirable reasoning upon them expressed in his paper,* "On the Changes of Temperature produced by the Rarefaction and Condensation of Air;" especially the way in which he takes into account any mechanical effect that may be externally produced, or internally lost in fluid friction, have introduced an entirely new method of treating questions regarding the physical properties of fluids. The object of the present paper is to show how, by the use of this new method, in connection with the principles explained in the author's preceding paper on the Dynamical Theory of Heat, a complete theoretical view may be obtained of the phenomena experimented on by Joule, and to point out some of the objects to be attained by a continuation and extension of his experimental researches.

The formulæ investigated in this paper are divided into three classes :—

1. Those which are certainly true for all substances, or for all fluids.

2. Those which are necessarily true for any fluid subject to Boyle's and Dalton's laws of density.

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* Phil. Magazine, 1845. Vol. xxvi., p. 369.

3. Those which would be true for every fluid subject to those laws of density, if "Mayer's hypothesis," that the heat evolved by compression, when the temperature is kept constant, is the exact equivalent of the work spent in the compression, were true for any one such fluid.

The principal formulæ of the first class are two which express respectively the quantity of heat evolved by the compression, by uniform pressure in all directions, of any substance whatever, kept at a constant temperature; and the total quantity of heat evolved by a given quantity of fluid forced through a small orifice, before it attains to precisely its primitive temperature.

The former of these formulæ reduces itself to

$$H = \frac{E}{\mu\,(1 + E\,t)} W$$

where W is the mechanical work spent in the compression, and H the quantity of heat emitted, for any fluid subject to Boyle's and Dalton's laws. This formula was first given in the Appendix to the author's Account of Carnot's Theory,—where it was shown to follow from Regnault's observations on the pressure and latent heat of saturated steam, that $\frac{\mu\,(1 + E\,t)}{E}$ cannot be nearly constant for all temperatures, if the density of saturated steam fulfils Boyle's and Dalton's laws; but that the value of this expression is very nearly J, the mechanical equivalent of a thermal unit, for ordinary atmospheric temperatures. Hence this theory, and the assumed density of saturated steam, are in full agreement with Joule's experiments which establish as approximately true for atmospheric temperatures the hypothesis which was assumed irrespectively of experimental verification, by Mayer.

The other formula mentioned above becomes, for a fluid subject to the "gaseous" laws,—

$$H = \left\{ \frac{1}{J} - \frac{E}{\mu\,(1 + E\,t)} \right\} p'\,u' \log \frac{p}{p'}$$

where p is the uniform pressure in one portion of a long tube; p' the uniform pressure in another portion, separated from the former by a piece of tube containing a partition with a very small orifice; t the temperature of the entering fluid up to the locality

where the rushing commences, and the pressure begins to vary, which is also the temperature to which the fluid is reduced in the other part of the tube before it reaches the end; and H the quantity of heat which must be taken away to fulfil this condition, during the passage of a quantity of fluid of volume u', under a pressure equal to p', at the temperature t, through the apparatus.

From this it follows, that the test of Mayer's hypothesis for any particular temperature is to try whether, when the air enters at that temperature, it leaves the *rapids* at precisely the same temperature. Calorimetrical methods of experimenting upon this apparatus, like those of Joule, but susceptible of being continuously used for any period of time, are suggested for determining, possibly with very great accuracy, the value of

$$\frac{1}{J} - \frac{E}{\mu\,(1 + E\,t)}$$

for any temperature, should it not be exactly zero for all temperatures, as it would be if Mayer's hypothesis were true. The value of J having been determined by Joule with very remarkable accuracy, it follows that such experimental researches, besides affording the solution of the problem which forms the subject of this paper, would determine the values of Carnot's function, by an entirely new method, for the temperatures of the experiments.

Dr Gregory exhibited a specimen of a beautiful fibrous silky white salt, taken about thirteen years ago, by Donald Campbell, Esq., from the joinings of the slabs of limestone forming the roof of the highest of the chambers of construction, discovered by Colonel Vyse above the King's Chamber in the great pyramid of Ghizeh. No other part is lined with limestone, and there only this salt appeared. Dr Gregory found it to be absolutely pure chloride of sodium, so pure, indeed, that it had not undergone the slightest change in thirteen years, although only wrapped in paper. Had lime or magnesia been present, it would have deliquesced. Under the microscope, the fibres exhibited oblique angles and fractures, and they may possibly be regular six-sided prisms, derived from the cube. Dissolved in water, the salt crystallized by evaporation in the usual form. When heated, it gave off a trace of water, but re-

tained its form and aspect. The origin of this salt is obscure; but it is probably derived from the limestone, which is known to be nummulite, and believed to be marine limestone.

The following Gentleman was duly elected an Ordinary Fellow:—

The Rev. Dr James Grant, Edinburgh.

The following Donations to the Library were announced:—

Journal of the Royal Geographical Society of London. Vol. XX., Part 2. 1851. 8vo.—*From the Society.*

Supplement to the Catalogue of the Athenæum Library. 8vo.—*From the Athenæum.*

Abhandlungen der Philosophisch-Philologischen Classe der K. Bayerischen Akademie der Wissenschaften. Bd. VI., Abtheil 1. 4to.

Abhandlungen der Historischen Classe der K. Bayerischen Akademie der Wissenschaften Bde. I.–VI., Abtheil 1. 4to.

Gelehrte Anzeigen herausgegeben von Mitgliedern der K. Bayerischen Akademie der Wissenschaften. Bde. XXX., XXXI. 4to.

Almanach der K. Bayerischen Akademie der Wissenschaften, für 1849. 12mo.—*From the Academy.*

Annalen der Königlichen Sternwarte bei München. Bd. IV. 8vo. —*From the Observatory.*

Abhandlung über das Schul. und Lehrwesen der Muhamedaner im Mittelalter. Von Dr D. Haneberg. 4to.—*From the Author.*

Ueber die Praktische Seite Wissenschaftlicher Thätigkeit. Von Fr. v. Thiersch. 4to.—*From the Author.*

Einige Worte über Wallensteins Schuld. Von Dr Rudhart. 4to.—*From the Author.*

Ueber die Politische Reformbewegung in Deutschland im XV. Jahrhunderte und den Antheil Bayerns an derselben. Von Dr Const. Höfler. 4to.—*From the Author.*

Bulletin de la Société de Géographie. 3me Série. Tom. XIV. 8vo.—*From the Society.*

The American Journal of Science and Arts. Vol. II., No. 32. 8vo.—*From the Editors.*

Experimental Researches on Electricity. By Michael Faraday, LL.D.—*From the Author.*

N° 41. d

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1851–2.

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[*Turn over.*

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